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VALIDATION TEAM MEETING
12–14 March 2019
Copernicus
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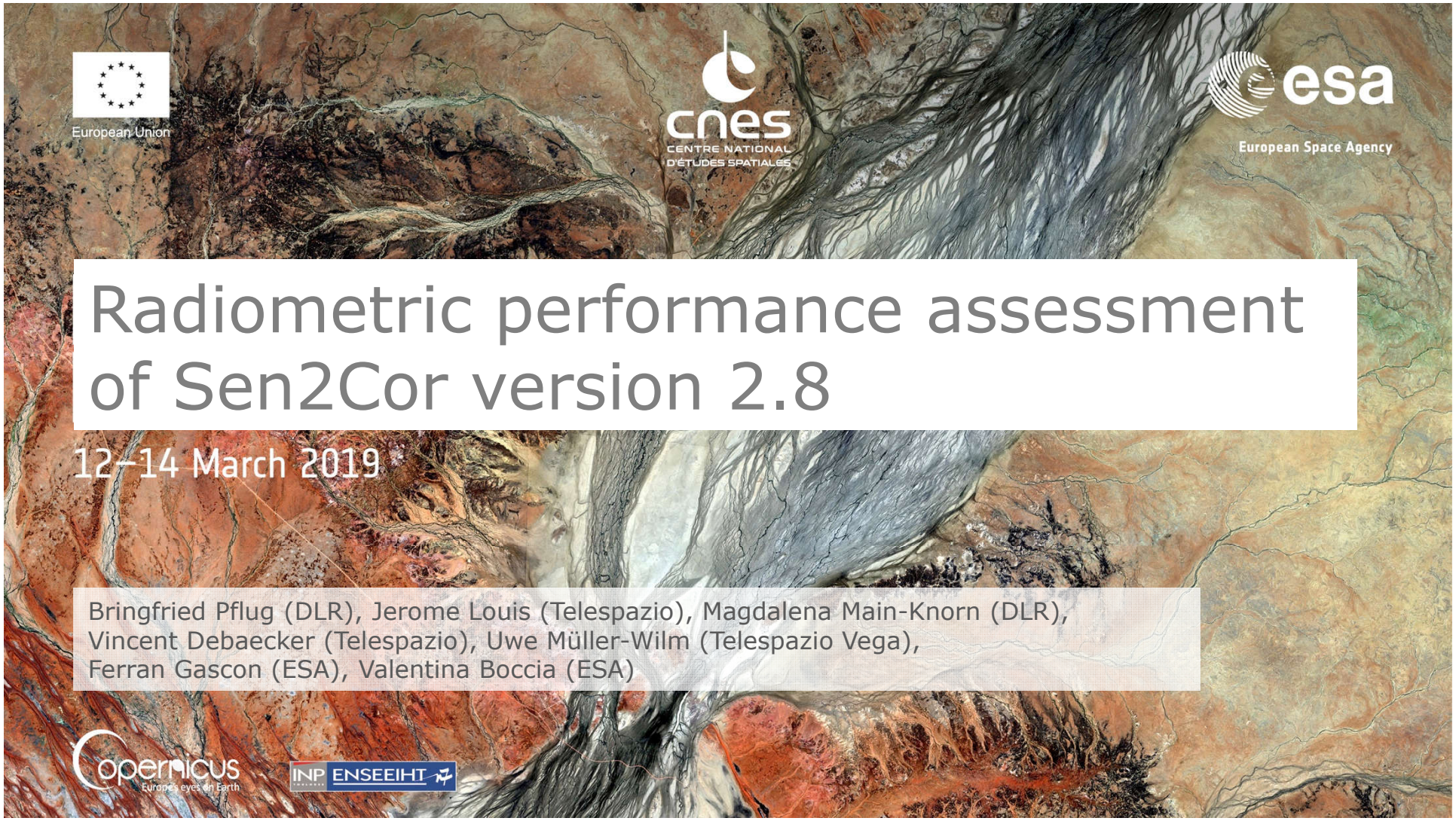

Radiometric performance assessment of Sen2Cor version 2.8

12–14 March 2019

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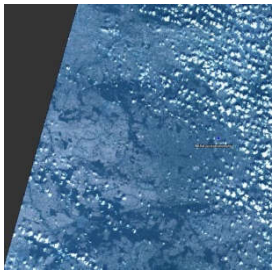
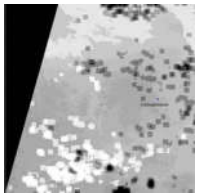
Outline

1. Sen2Cor Processor
2. Validation procedure
3. Validation data set

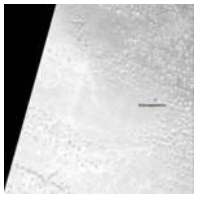
4. Validation results for AOT product (2.8)
5. Validation results for WV product (2.8)
6. Validation results for SR product (2.5)



TOA-RGB (L1C-input)



AOT map

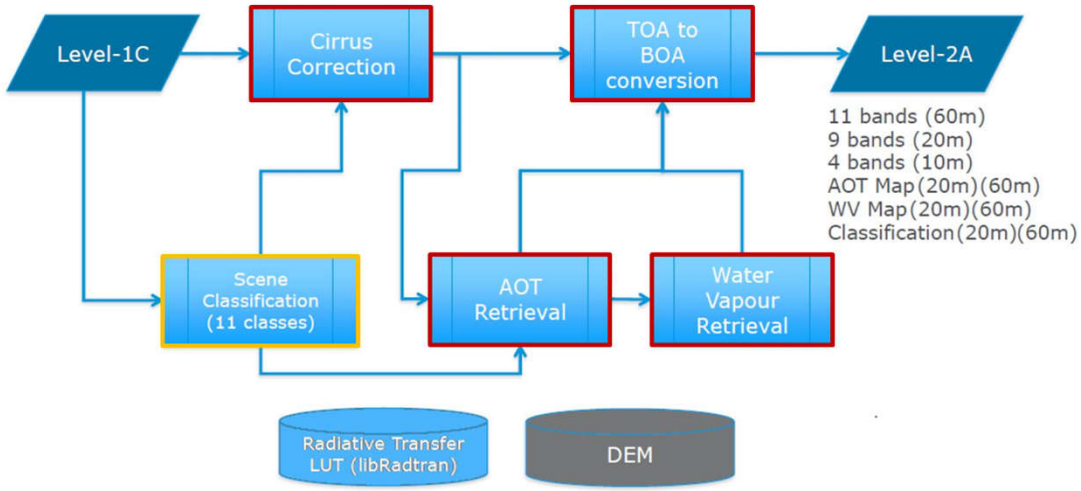


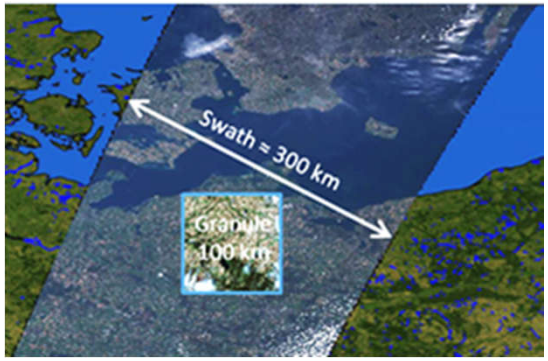
WV map

BOA-RGB (L2A-output)

Sen2Cor processor overview

- Atmospheric correction processor for **Sentinel-2 data**
  - Tool for Sentinel-2 mission
  - Atmospheric Correction over land surface
  - Processing **mono-temporal** orthorectified **L1C granules**
  - Two main modules : Scene Classification (SCL) and Atm. Correction (AC)





- SCL: series of threshold tests on L1C spectral bands, band ratios and indices
- AOT (550 nm): DDV-algorithm
- Optional cirrus correction preprocessing
- WV retrieval: Atmospheric Pre-corrected Differential Absorption Algorithm (APDA)
- BOA: terrain correction, adjacency corr., empirical Bidirectional Reflectance Distribution Function (BRDF) corrections

Validation procedure

Sen2Cor processing:

- rural aerosols
- summer profile
- ozone content from metadata
- no cirrus correction
- terrain correction with SRTM-DEM

AOT & WV validation:

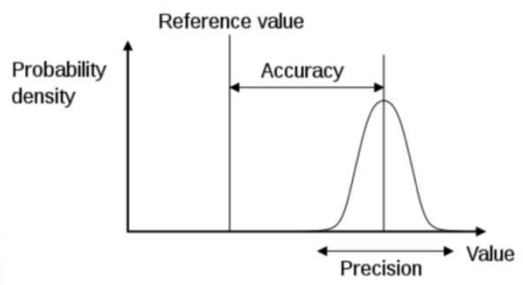
- direct comparison with AERONET
- satellite overpass time ±15 min
- 9km x 9km area around sunphotometer
- all vegetated, non-vegetated and and snow pixels

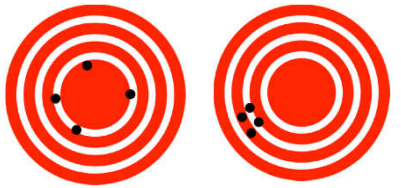
BOA-validation:

- Pixel-by-pixel comparison with AERONET corrected (surface reflection) data:
- Considered only non-saturated, non-cloudy pixels

statistical metrics:

- Accuracy (A): median difference to reference value
- Precision (P): rms around mean value
- Uncertainty (U): rms around reference value

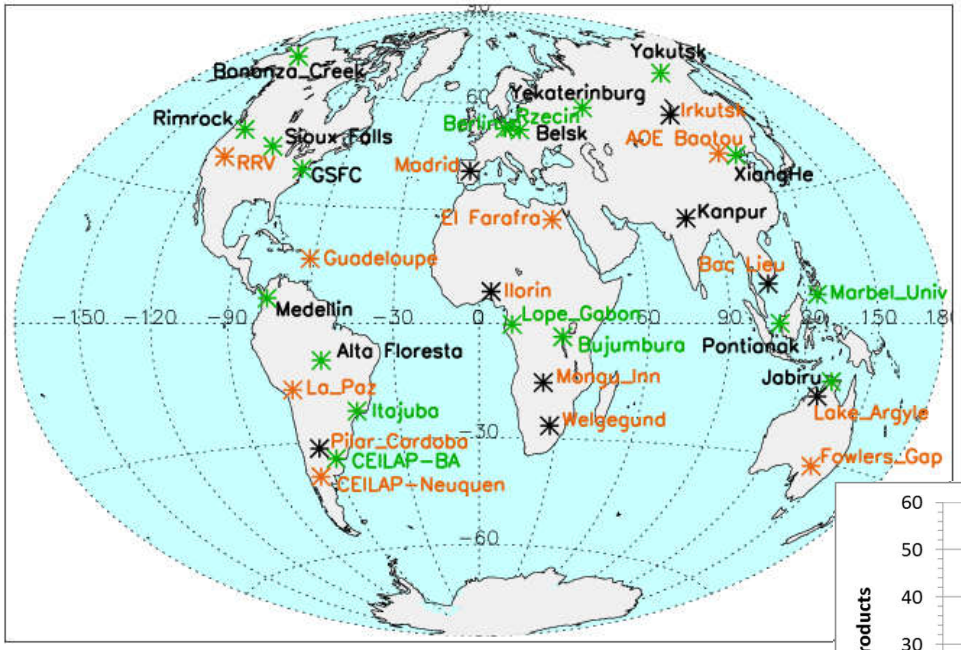




High accuracy, but low precision

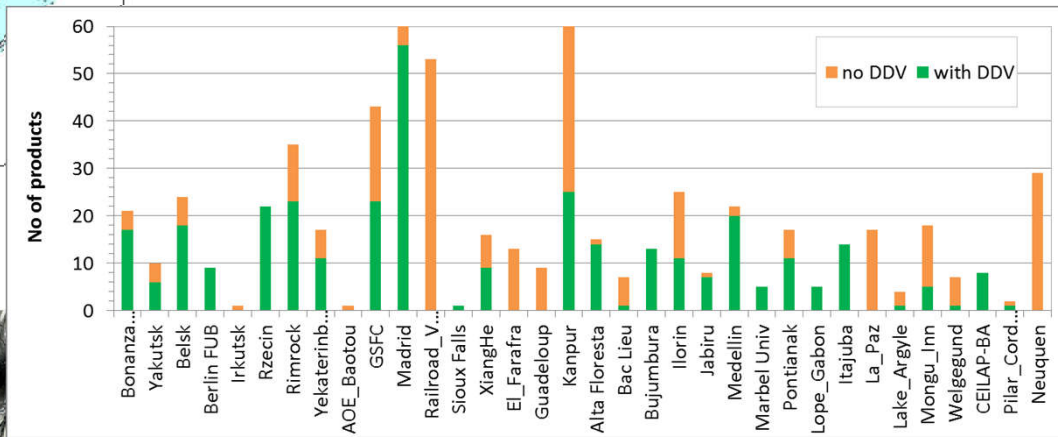
High precision, but low accuracy

Validation data set (AOT and WV)

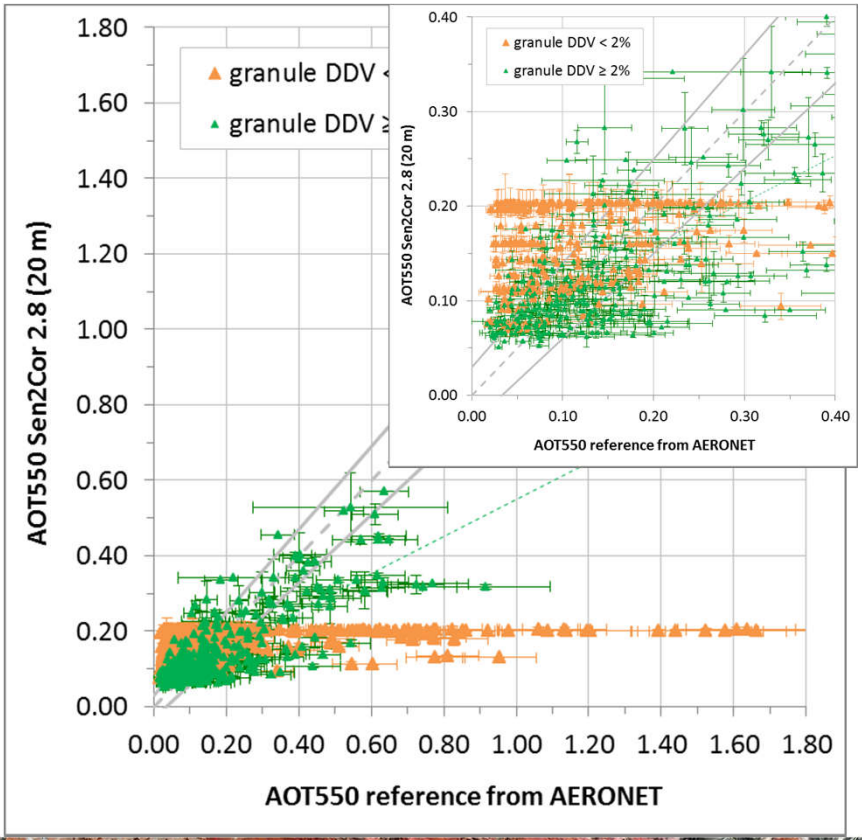


- 703 granules from 2017-2019
- from 36 test sites over all climate zones

- 337 DDV, 365 noDDV
- 371 nearly cloudless, 331 cloudy



AOT validation Sen2Cor 2.8



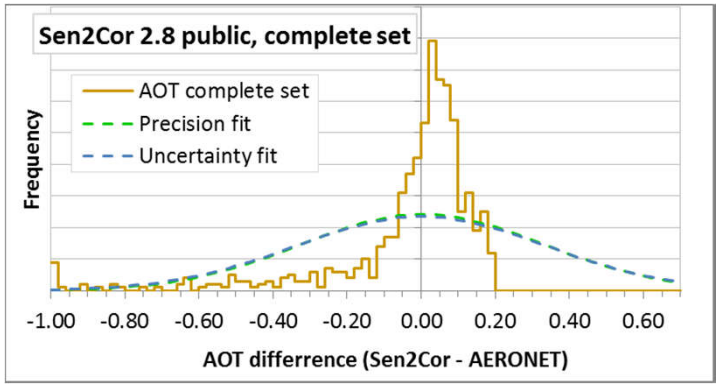
› **solid lines**: Accuracy requirement
$|\Delta AOT550| \leq 0.1*AOT550_{ref}+0.03$

› **Dashed line**: Sen2Cor_output = Reference

› **Green triangles**: Results for **DDV**-algorithm

› **Orange triangles**: **fall-back** processing

› Linear trend line for DDV processing



- Trend: Underestimation of higher AOT550 values
- Applied fallback processing (with configured start VIS=40 km) gives many large outliers

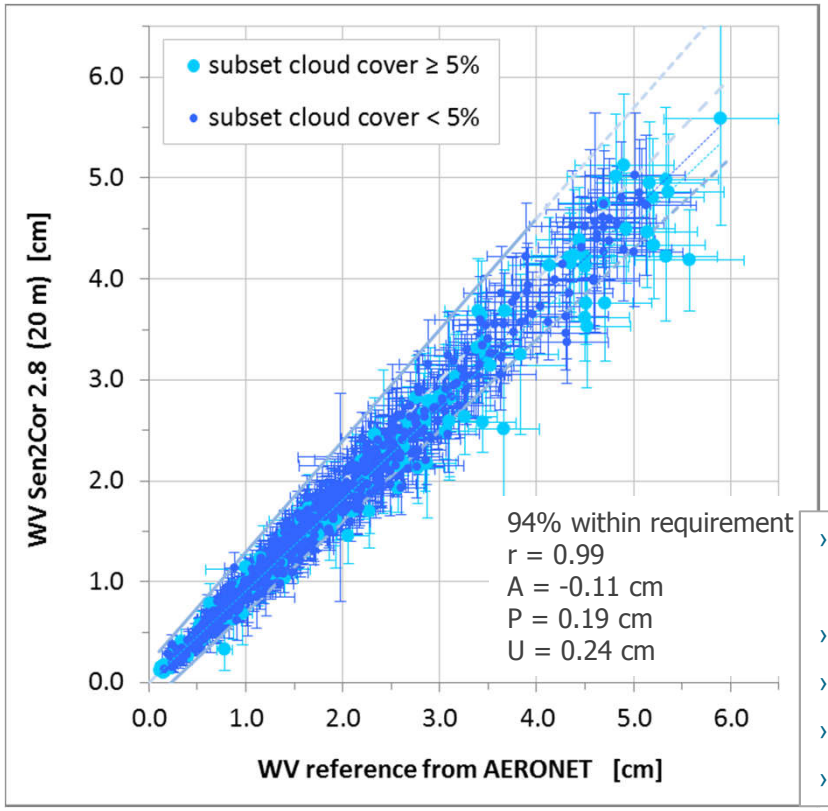
⇨ new fallback solution

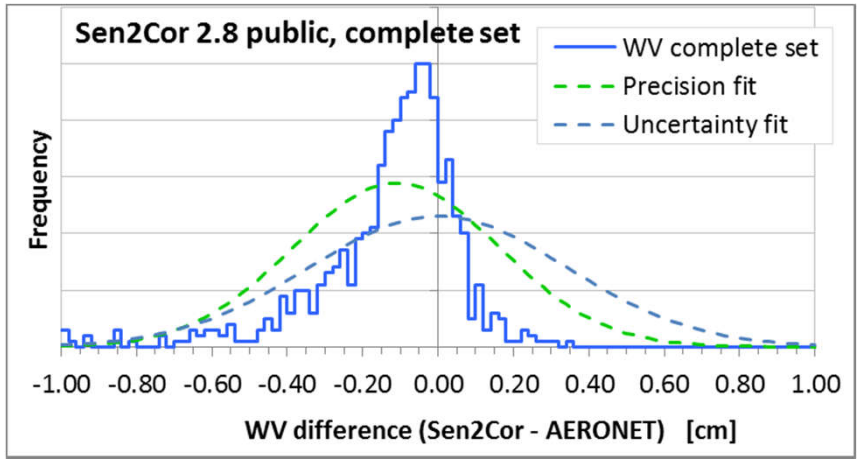
AOT validation Sen2Cor 2.8

	complete set	DDV subset		DDV subset S2A	DDV subset S2B		Complete set summer	Complete set winter
No. of products	702	337		160	177		459	243
within requ.	36%	48%		46%	49%		39%	30%
r (Pearson's corr.)	0.45	0.80		0.78	0.81		0.44	0.50
Accuracy (A)	0.004	-0.01		-0.01	-0.01		0.003	0.01
Precision (P)	0.23	0.10		0.10	0.10		0.18	0.30
Uncertainty (U)	0.24	0.11		0.10	0.11		0.19	0.31

- Acceptable APU for DDV subset, complete set will become better with new fallback solution
- No significant difference between performance of DDV-algorithm for S2A and S2B data
- Data set for winter quite small, dominated by low AOT-values
  Winter data give worse performance for investigated data set

WV validation Sen2Cor 2.8

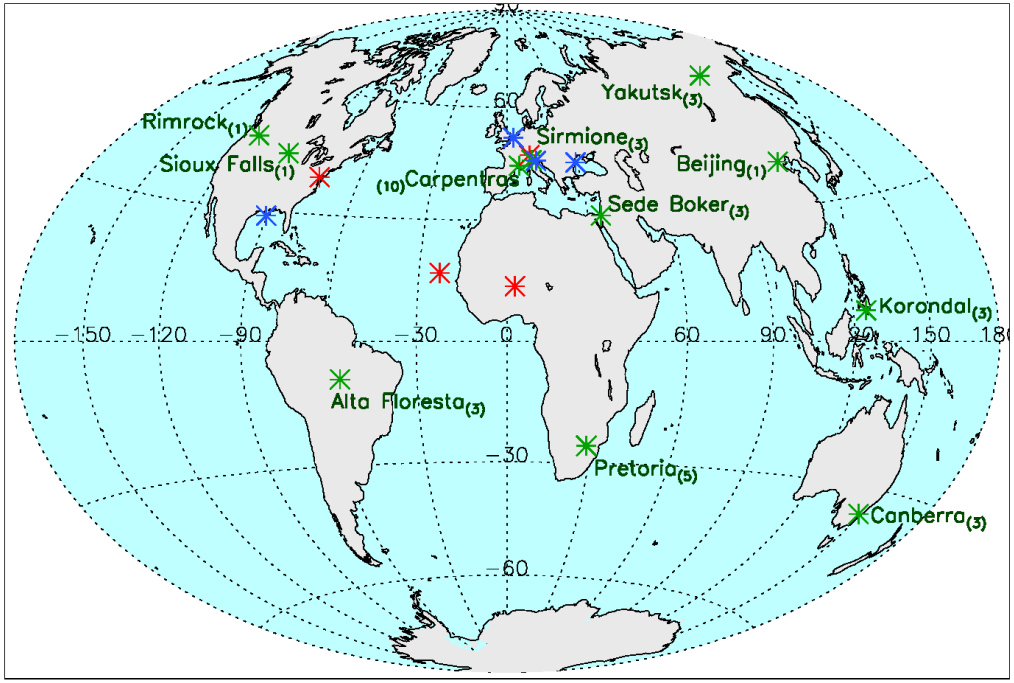




› **solid lines**: Accuracy requirement
|ΔWV| ≤0.1*WVref+0.2
› **Dashed line**: Sen2Cor_output = Reference
› **Blue Circles**: Results for **cloud cover <5%**
› **Cyan circles**: Results for **cloud cover ≥ 5%**
› Linear trend line

- Trend: little underestimation of WV

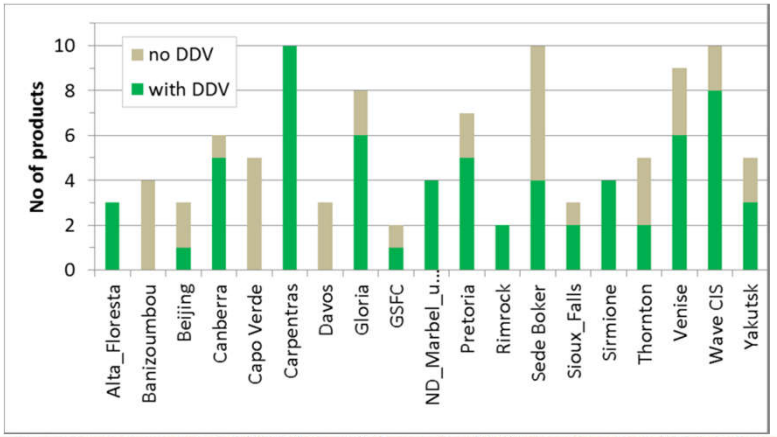
Validation data set (SR)



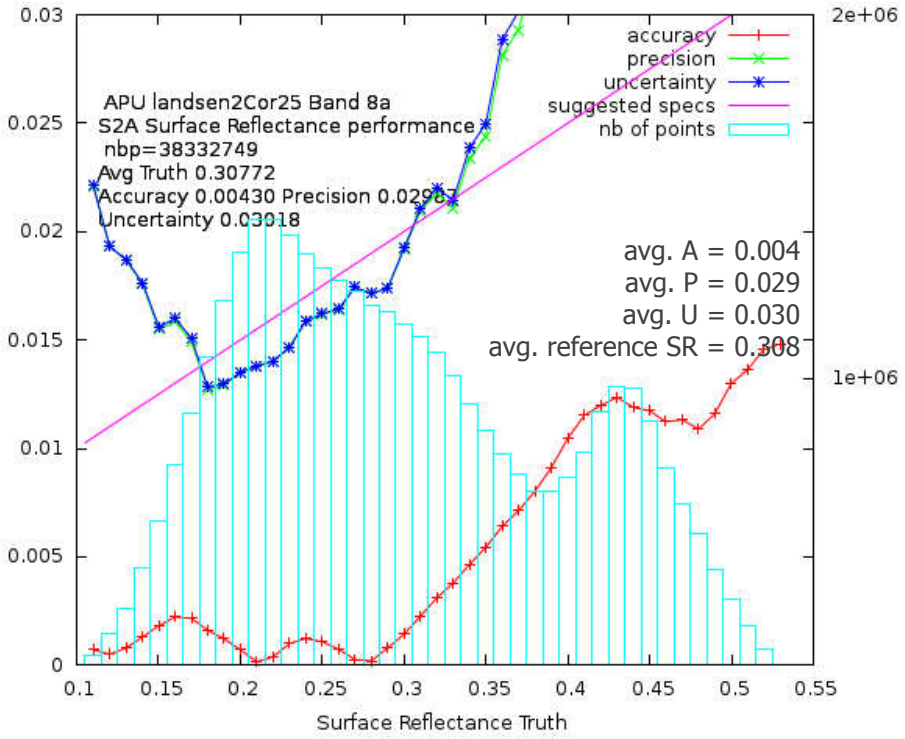
* Vegetation (DDV) site * arid (noDDV) site * water site

- 67 granules from January to July 2016
- from 11 test sites over all climate zones

- 37 DDV, 30 noDDV



SR validation Sen2Cor 2.5 (Band 8a)



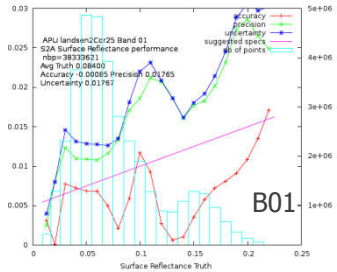
- APU Analysis: [Eric Vermote]

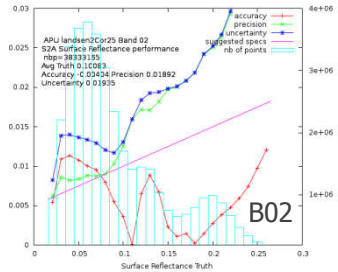
- Pixel-by-pixel comparison with AERONET corrected (surface reflection) data
- Plotted are average results over 19 test sites including arid locations
- ACIX-1 data set !!! (January to July 2016)

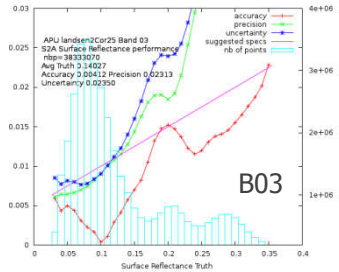
- specs: $0.05\rho^{ref} + 0.005$
- Very detailed performance assessment

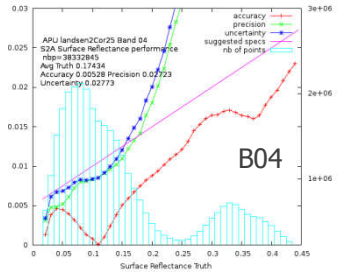
➢ Accuracy well within requirement
➢ Uncertainty (and Precision) within requirement for large amount of pixels

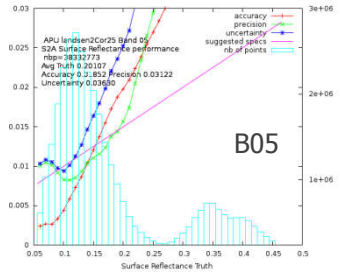
SR validation Sen2Cor 2.5 (all bands)

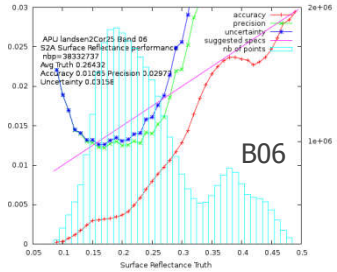


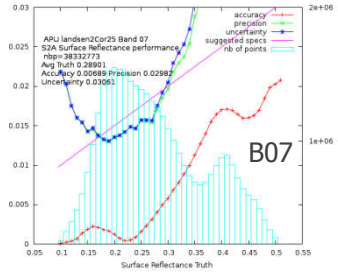


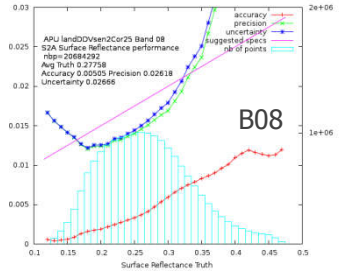


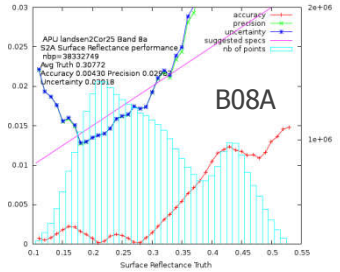


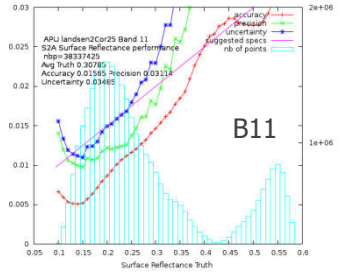


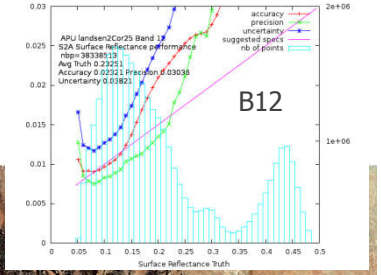




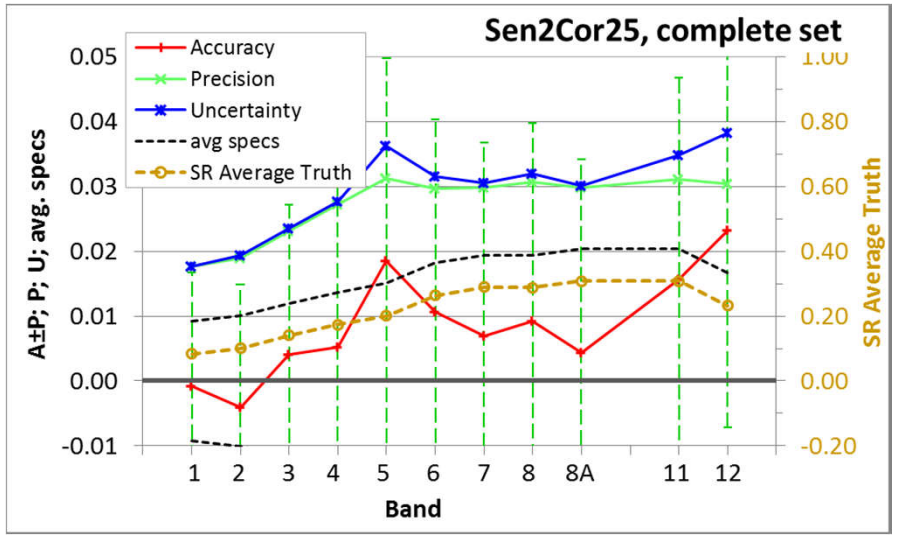


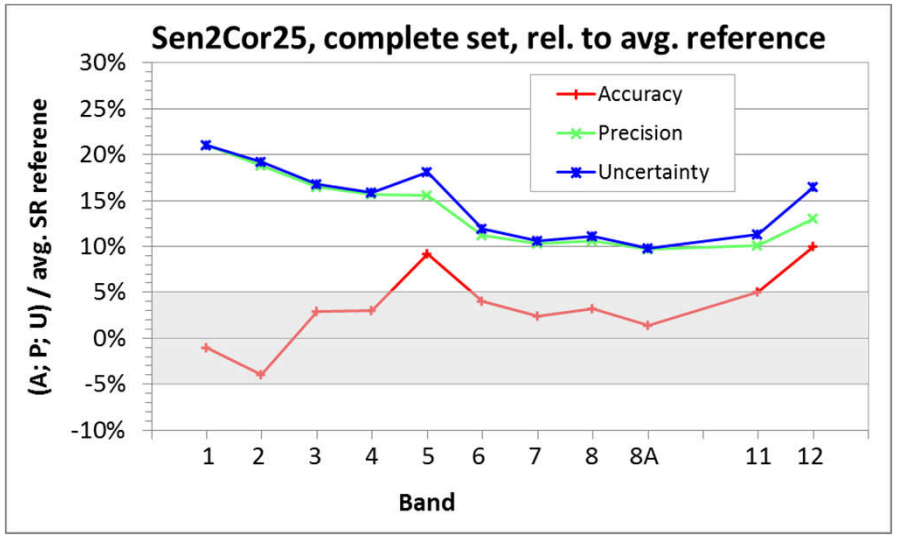






SR validation Sen2Cor 2.5 (Band average)





Band average accuracy:

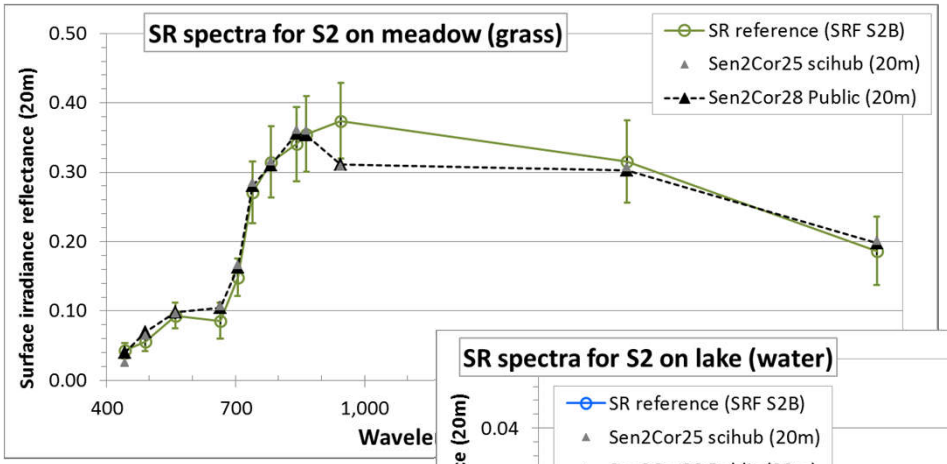
- Value increasing with wavelength
- within specs and within 5% relative to reference except band 5, 12

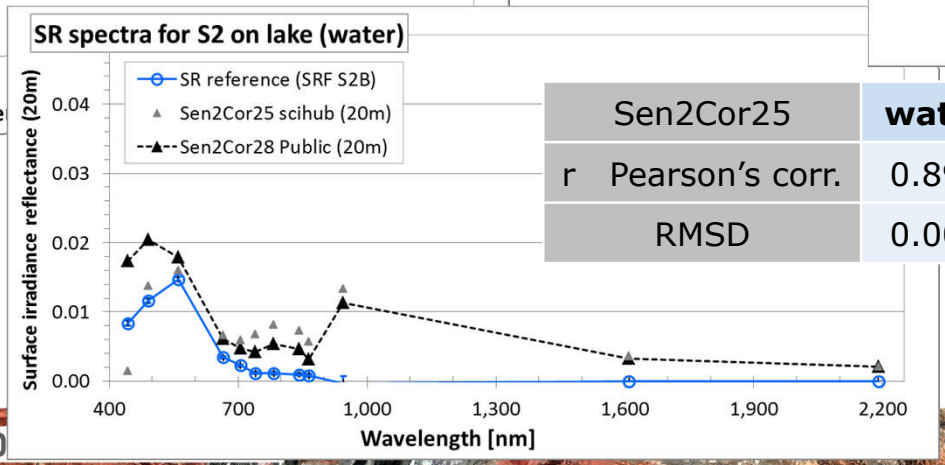
Band average uncertainty and precision:

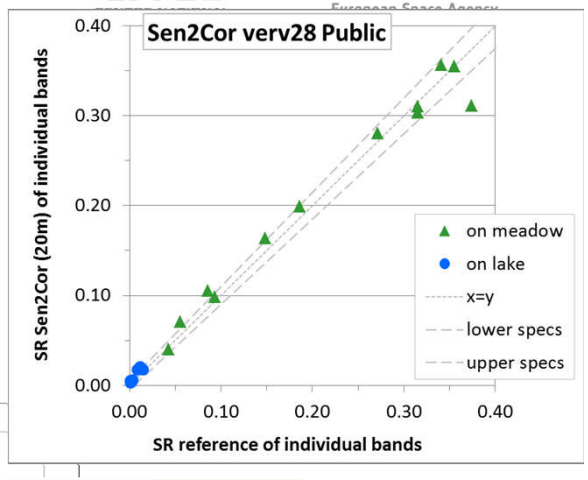
- absolute valuse for P and U increase, relative values P and U decrease with wavelength
- outside 5% relative to reference

Sen2Cor SR retrieval compared with SR measured on ground

Example data: 04.05.2018, Lake Stechlin, Northern Germany (53.15°N, 13.03°E)



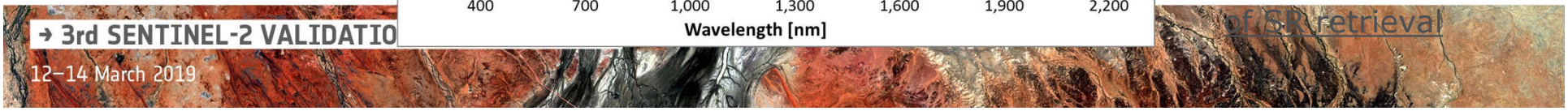




NDVI	Grass
Sen2Cor25	0.54
reference	0.53
Sen2Cor-reference	0.01

Sen2Cor25		water	grass
r	Pearson's corr.	0.897	0.973
	RMSD	0.005	0.022

- Good shape and intensity correctness of SR retrieval



Summary

- Processor performance for Sen2Cor 2.8 further improved

- AOT estimation: A = 0.004, P = 0.23, U = 0.24, 36% within specification
- WV retrieval: A = -0.1 g/cm^2, P = 0.2 g/cm^2, U = 0.2 g/cm^2, 94% within specification

- BOA reflectance: Results still for Sen2Cor 2.5
- Accuracy (A), Precision (P) and Uncertainty (U) are within specification for large amount of pixels
- Good shape and intensity correctness of SR retrieval relative to reference measurement on surface

- Validation with AERONET-corrected surface reflectance as reference must be supplemented by more measurements

establishment of permanent working test sites, ad-hoc campaigns

Thank you for your attention !

Radiometric performance assessment of Sen2Cor version 2.8

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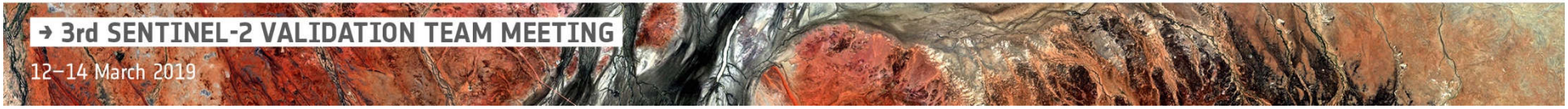
ACKNOWLEDGEMENT: The authors thank the PI investigators and their staff for establishing and maintaining the AERONET sites used in this investigation.



AOT550 retrieval ranking per climate zone

➔ Sen2Cor 2.8 public

Complete set	Total no. of products	Products within requ.	**U** (Uncertainty)	Fraction of DDV products
Polar	31	48%	± 0.06	74%
Temperate	108	47%	± 0.12	77%
Subtropical S	60	42%	± 0.07	35%
Midlatitude N	247	39%	± 0.10	36%
Tropical	117	37%	± 0.29	75%
Subtropical N	97	16%	± 0.51	26%
Midlatitude S	42	7%	± 0.12	21%

DDV subset	Total no. of products	Products within requ.	**U** (Uncertainty)
Midlatitude N	89	60%	± 0.07
Subtropical S	21	52%	± 0.05
Polar	23	52%	± 0.05
Temperate	83	49%	± 0.08
Tropical	87	39%	± 0.14
Subtropical N	25	32%	± 0.18
Midlatitude S	9	22%	± 0.06

➔ DDV subset: All of polar, temperate, midlatitude N and subtropical S perform similar
- › Significant worse performance in Tropics
- › Worst performance: subtropical N, but it is 1 only test site (Kanpur)

AOT550 retrieval ranking per climate zone

➔ Sen2Cor 2.8 public

DDV subset top 11 with at least 5 products	Total no. of products	Products within requ.	**U** (Uncertainty)
Berlin_FUB	9	78%	± 0.05
POLWET_Rzecin	22	73%	± 0.05
Madrid	56	64%	± 0.05
Alta_Floresta	14	64%	± 0.05
Mongu_Inn	5	60%	± 0.05
Bonanza_Creek	17	59%	± 0.05
GSFC	23	57%	± 0.09
Itajuba	14	50%	± 0.04
Rimrock	23	48%	± 0.06
Bujumbura	13	46%	± 0.14
Yekaterinburg	11	45%	± 0.06

DDV subset worst 11 with at least 5 products	Total no. of products	Products within requ.	**U** (Uncertainty)
Pontianak	11	45%	± 0.15
XiangHe	9	44%	± 0.13
Marbel_Univ	5	40%	± 0.06
Lope_Gabon	5	40%	± 0.25
Medellin	20	35%	± 0.08
Yakutsk	6	33%	± 0.05
Kanpur	25	32%	± 0.18
Jabiru	7	29%	± 0.06
CEILAP-BA	8	13%	± 0.07
Belsk	18	11%	± 0.13
Ilorin	11	0%	± 0.26